Environmental Assessment and Specification of Green Building Materials

by Lynn M. Froeschle

As the earth's population continues to explode and developing nations begin to use their share of the world's resources, it is necessary to ascertain how we, as a planet, use our earth's precious resources. The United States consumes nearly 25 percent of the world's energy, yet has only 5 percent of the earth's population.[1] Over one-third of this energy is consumed by buildings.[2] This does not consider the amount of embodied energy used in the manufacture of building materials or the finite resources used in product composition.

During construction or at the end of useful building life, construction materials and components are often discarded with construction debris accounting for nearly 28 percent of landfill waste in this country.[3] Inappropriate use of building materials that emit chemicals can pollute the indoor environment contributing to poor indoor air quality (IAQ) with some new building chemical concentrations up to 100 times greater than outside levels.[4] With Americans spending nearly 90 percent of their time indoors,[5] it is not surprising that The World Health Organization estimates approximately 30 percent of all buildings will have IAQ concerns during the facility's occupancy.[6] Green or environmentally friendly materials can help create more sustainable, healthful, and ecologically sensitive buildings. This is achieved through environmental material assessment and green building specifications. It is crucial for the specifications to be enforced during construction to ensure an environmentally friendly application of materials. When the building is complete, sustainable facility maintenance practices help ensure the improved performance of green building materials and ultimately the environmental green building.

Environmental Material Assessment

The assessment of environmental materials begins with establishing criteria for evaluating building materials. The criteria should compliment the overall environmental project goals. Often extensive research is necessary to evaluate prospective products. Based on the environmental material criteria established for a green building project, selection of appropriate building products and systems can be accomplished.

The environmental material criteria may vary per project. Criteria may also vary depending on whether a project is new construction, a renovation of an existing building, or whether site work is associated with the project. The following are recommended environmental material criteria for use in green building product or system assessment and evaluation:

- Low toxicity: Materials the manufacturer demonstrates to have reduced toxicity or are nontoxic and avoid carcinogenic compounds and ingredients.
- Minimal emissions: Products that have minimal chemical emissions, emit low or no volatile organic compounds (VOCs), and avoid the use of chlorofluorocarbons (CFCs).
- Low-VOC assembly: Materials installed with minimal VOC-producing compounds or no-VOC mechanical attachment methods and minimal hazards.
- Recycled content: Products with identifiable recycled content in the material including post-industrial content with a preference for post-consumer content.
- Resource efficient: Products manufactured with resource-efficient processes including reducing energy consumption, minimizing waste, and reducing greenhouse gases.
- Recyclable: Materials that are recyclable at the end of their useful life.

ADDITIONAL INFORMATION

Author

LYNN M. FROESCHLE, CSI, AIA, is principal of Lynn Froeschle, AIA, Architects in San Diego, California, specializing in environmentally sustainable architecture and green building consultation. Ms. Froeschle can be reached at LFroeschle@aol.com.

MasterFormat No.

00340—Environmental Assessment Information

Key Words

**environmental material assessment
indoor air quality
volatile organic compounds
chlorofluorocarbons
material safety data sheets**

Abstract

As the earth's population continues to grow, we must be more aware of how we use the earth's natural resources. Through the assessment and specification of green building materials, the built environment can be enhanced without harmful effects on the natural environment.

Editor's Note

This article is based on the "Environmental Assessment and Specification of Green Building Materials" paper authored by Lynn M. Froeschle, CSI, AIA, and presented at Green Building Challenge '98 sponsored by Natural Resources Canada and CANMET Energy Technology Centre.

- Reusable: Building components that can be reused or salvaged.
- Sustainable: Renewable natural materials harvested from sustainably managed sources and preferably that have an independent certification.
- Durable: Materials that are longer lasting or are comparable to conventional products with long life expectancies.
- Moisture: Products and systems that resist moisture or inhibit the growth of biological contaminants in buildings.
- Energy efficient: Materials, components, and systems that help reduce energy consumption in buildings and facilities.
- Water conserving: Products and systems that help reduce water consumption in buildings and conserve water in landscaped areas.
- Improves IAQ: Systems or equipment that promote healthy IAQ by identifying indoor air pollutants or enhancing the air quality.
- Healthfully maintained: Materials, components, or systems that require only simple, nontoxic or low-VOC methods of cleaning.
- Local product: Building materials, components, and systems found locally or regionally saving energy and resources in transportation to the project site.
- Affordable: Building product life-cycle costs comparable to conventional materials or as a whole, are within a project-defined percentage of the overall budget.

The environmental assessment of green building materials can be broken into three phases: research, evaluation, and selection. The most time-consuming aspect of the three-part process is research. Evaluation can be equally difficult and dependent on product information provided by manufacturers that is often incomplete as it relates to environmental issues. Since there is currently no standard format for providing environmental product information, interpreting and comparing product information can also be difficult. When selecting green building materials, environmental criteria and proper application of the materials should be considered. The following are the three phases of the environmental assessment process.

Research. This includes gathering information directly from manufacturers such as obtaining material safety data sheets (MSDs), IAQ test data (if available), environmental statements, recycled content data, durability information, and product warranties. Additional information sources include the various resource guides currently available. Due to the variability and, in some cases, inaccuracies in resources, most guides should be considered only as a starting point for which additional research is required. If a guide is not updated, the information can become obsolete due to the evolving nature of environmental building materials or modifications in green product lines.

Evaluation. Once research and information gathering is complete, evaluation can begin. Evaluation often includes confirmation of the information provided by manufacturers and requests for missing or incomplete data. Evaluation can be a frustrating process since some manufacturers may exaggerate product environmental qualities, whereas others may not recognize the environmental attributes that apply to their products. Additional information to review includes MSDS and IAQ test data from independent laboratories. However, the MSDS may not indicate all the ingredients of a product nor include proprietary compounds. Material composition can often change, even within the course of the building project. This can be alleviated by requesting letters of clarification from the manufacturer. Reviewing product warranty and durability test information is also important. Evaluation and assessment can be accomplished by comparing similar types of building materials based on the environmental criteria.

Selection. Green building material selection is based on the product that best meets the established environmental criteria and the most appropriate application for the project. When comparing similar types of products, a rating system can be established by giving higher points to products that meet the environmental criteria and lower points to materials that do not meet the criteria. By totaling the points, an "environmental" score or rating can be ascertained. Sometimes a product may have strengths in some areas

Figure A. Environmental material assessment matrix
(compare similar product categories)

Environmental Criteria	Prod. "A"	Prod. "B"	Prod. "C"
Low Toxicity			
Minimal Emissions			
Low-VOC Assembly			
Recycled Content			
Resource Efficient			
Recyclable Materials			
Reusable Components			
Sustainable Sources			
Durable Materials			
Moisture Resistant			
Energy Efficient			
Improved IAQ			
Water Conserving			
Healthful Maintenance			
Local Product			
Affordable Material			
Environmental Score:			

ALL ILLUSTRATIONS COURTESY THE AUTHOR

but may have a characteristic causing enough concern to not be selected if it does not meet the project's environmental goals. Selected green building materials are then incorporated into the project specifications. The matrix in *Figure A* can be used as a tool to compare and assess similar green building materials in like categories.

Greening Project Specifications

The greening of project specifications can occur in three forms: environmental procedures, environmentally friendly products, and environmental applications.

Environmental procedures. This section should be added to Division 1 stating the project environmental goals and the general environmental procedures that address healthy IAQ, environmental construction techniques, building component reuse, and construction recycling. References to local, state, federal, and industry environmental standards, regulations, and requirements should be included along with specific chemicals to be avoided within the project; the material types that can be reused, salvaged, or recycled; and a list of local recyclers. This section can also include healthful building maintenance procedures for use during construction.

Environmentally friendly building materials. Green building materials should be incorporated into their respective sections within project specifications. Product specifications should include the unique product qualities that make it an environmentally friendly material such as low toxicity, minimal chemical emissions, recycled content, recyclability, durability, moisture resistance, and environmental and ecological installation procedures. The specifications should include specific environmental product characteristics such as toxic chemicals the product does not contain (e.g., formaldehyde free, etc.) and identify the actual recycled content including the percentage of post-industrial or post-consumer recycled content.

Environmental applications. Project specifications should also be reviewed in their entirety and specific environmental procedures should be included wherever possible, even for use with conventional products such as low-VOC adhesives for installation. The complete greening of project specifications also provides an opportunity to eliminate procedures that conflict with the project goals and the general environmental procedures listed in Division 1. *Figure B* shows a sample environmental specification outline for an individual section based on CSI's three-part *SectionFormat*™.

Figure B. CSI *SectionFormat*™ for environmental specifications of products

Part 1 General

1. **Environmental Requirements**
   - a) List applicable environmental standards, regulations, and requirements.
   - b) Include VOC requirements.
   - c) List recycled content requirements.
   - d) Identify reuse, recycling, and salvaging methods.
   - e) Reference Division 1 Environmental Procedures for Construction.
     - i) VOCs or chemicals to avoid.
     - ii) General environmental procedures.
     - iii) Reuse, recycling, or salvaging requirements.
     - iv) Healthful building maintenance.

Part 2 Products

2. **Specific Environmental Product Attributes**
   - a) Product contains no XXXX chemical(s) (list and identify)
   - b) Product contains XX% recycled content:
     - i) Identify post-industrial recycled content.
     - ii) Identify post-consumer recycled content.
   - c) Product is recyclable after useful life.
   - d) Product is certified by an independent third party:
     - i) Recycled content.
     - ii) Sustainably harvested.
   - e) Product is durable (list warranty).
   - f) Product is moisture resistant (if applicable).
   - g) Include any other environmental attributes.

Part 3 Execution

3. **Environmental Procedures**
   - a) Address environmental installation of materials.
   - b) Include protection of materials.
   - c) Identify environmental methods of clean-up.
   - d) Include recycling of scrap during construction.
   - e) Reference Division 1 Environmental Procedures.

Environmental Construction Materials

Implementing environmental practices during construction is a challenge requiring cooperation with the contractor. In the emerging field of sustainable architecture, it is not always possible to enlist a contractor with prior environmental construction experience. Since it is important that the general contractor and subcontractors understand the environmental specifications, a preconstruction meeting addressing sustainable approaches to construction is beneficial. In facilitating the successful green project, it is crucial that the specified green materials and environmental procedures are monitored and enforced during construction to ensure the products are installed using ecological construction practices (see *Figure C*, page 56).

The following are key points to consider during construction:

- Green building materials. Confirm that the specified green building materials are actually being installed. Avoid "substitutions" unless the contractor can prove they are equal in environmental quality to the originally specified product.
- Environmental construction techniques. A preconstruction meeting to discuss the specified environmental procedures is an important step in the ecological construction process. Verify the contractor is installing the green building materials with the specified low-VOC sealers and adhesives or with the no-VOC mechanical methods of attachment.

- Healthy IAQ. Before construction, require from the contractor a healthy IAQ plan that enhances the specified environmental procedures. Once approved, verify the contractor is implementing the plan, which should include installing low-VOC "wet" material applications before "dry" fibrous materials, thereby minimizing the absorption of chemical emissions in the fibrous products.
- Resource efficiency. Before construction, require from the contractor a reuse, recycling, and salvaging plan that enhances the specified environmental procedures. Once approved, confirm that the contractor is implementing the plan which should include reuse or salvaging of existing building components and recycling both demolition debris and new construction waste.
- Construction recycling. Require source-separated recycling of construction debris from both new and existing buildings. Typical recyclable building materials include: asphalt, brick, cardboard, ceramics, concrete, glass, gypsum board, landscaping cuttings (greens), ferrous (steel) and nonferrous (aluminum, copper, etc.) metals, and wood.
- Healthful building maintenance. Procedures for healthful building maintenance during construction should also be included in the specified environmental procedures and addressed in the IAQ plan. This should include low or no-VOC cleaning methods of the green building finishes before occupancy.

Sustainable Maintenance

Once a building is complete, sustainable maintenance of the building materials is important in extending the useful life of the materials, increasing resource efficiency, and improving IAQ. Often overlooked, sustainable and healthful building operation and maintenance is key to keeping an environmental building and the materials "green." Healthful building maintenance enhances both the natural and built environments and improves the well-being of the building occupants. The following are points to consider for sustainable maintenance of green building materials:

- Extended useful life. By using sustainable and healthful building maintenance procedures, the useful life of building materials, components, and systems can be extended. This reduces the negative impact on the natural environment while providing the owner fiscal savings with fewer materials to replace less often.
- Healthy IAQ. Maintenance procedures that incorporate nontoxic cleaning methods and least-toxic pest control should be used to maintain a healthy indoor environment. This benefits both the materials and the occupants, who generally are more productive in a healthful environment. Healthful maintenance procedures can also apply to building systems ensuring a continued healthy indoor air quality for the building occupants.
- Resource efficiency. Sustainable maintenance of environmental building materials includes the refurbishing, salvaging, or recycling of the materials. This occurs when there is a remodel or the materials have reached the end of their useful life. By reusing or recycling building materials, one life cycle of the material is complete, and another begins for the product as either a refurbished or new material with recycled content.

Figure C. Basic environmental construction procedures

1. Provide a healthy indoor air quality plan for construction.
2. Prepare a construction reuse, salvaging, and recycling plan.
3. Provide temporary ventilation and exterior air changes to the construction space.
4. Install the specified green building products including the specified low-VOC sealants and adhesives.
5. Install low-VOC "wet" applied materials and allow to dry or cure before installing fibrous "dry" materials where feasible.
6. Protect finish surfaces from dust, particulates, and VOCs.
7. Use construction methods that minimize airborne particulates.
8. Recycle construction debris and material waste.
9. Refurbish and reuse existing building components where specified.
10. Salvage usable components for off-site reuse.
11. Implement construction methods that minimize waste.
12. Clean up daily using methods that do not create dust and that use nontoxic cleaning methods.

Green Material Performance

The performance of green building materials, as with conventional building products, depends on the durability, appropriate application, and proper maintenance of the product. Often, green building materials are given more scrutiny than their conventional material counterparts because they tend to be newer with less proven performance. This is when extended warranties are important. The following case study indicates that green building materials have been and are being used successfully in sustainable building projects demonstrating that products with recycled content or minimal chemical emissions can perform as well or better than conventional building products.

Green building products were successfully implemented into The Ridgehaven Green Office Building, the award-winning sustainable and economical renovation of an existing 6800 m^2 (73,000 ft^2) office building for the City of San Diego Environmental Services Dept. in California. This sustainable facility showcases environmentally friendly building materials, healthy IAQ, resource efficiency through reuse and recycling, energy-saving systems, and water conservation. Selection of materials was based on similar criteria as noted in this article. The following are examples of green building materials that have been performing in the facility since 1996: [7,8]

- Low-VOC paints, sealers, and stains. Water-based latex paints meet South Coast Air Quality Management Districts (SCAQMD) requirements for low-VOC coatings and contain no formaldehyde, petroleum-based solvents, or other toxins.

- Acoustical ceiling tiles. The naturally nonflammable and antimicrobial perlite content ceiling tiles emit no VOCs. The tiles with man-made mineral fibers contain 10 percent post-industrial recycled perlite content and also are recyclable.
- Carpet tiles. The tiles met State of Washington Indoor Air Quality Specification criteria for low-VOC products. The backing has antimicrobial properties and was installed with minimal use of low-VOC adhesive. The tiles have 13 percent post-industrial recycled nylon content face fiber, are reusable, and are recyclable after useful life.
- Carpet base. The carpet base contains ten percent post-industrial recycled rubber content and is recyclable.
- Linoleum sheet flooring. The natural material components have minimal VOCs, natural antimicrobial characteristics, 10 percent post-industrial recycled content, and a natural and renewable resource composition.
- Ceramic tile. Glass and clay content tiles are inherently inert and do not emit VOCs. They contain 70 percent post-industrial and post-consumer recycled glass bottles, and are recyclable.
- Cellulose insulation. The blow-in cellulose insulation was manufactured without formaldehyde, and contains newspapers with soy ink, and a nonhazardous fire-retardant. It is 100 percent post-consumer newsprint fiber and recyclable.
- Fiberboard. Medium density fiberboard (MDF) was manufactured without formaldehyde. Ninety percent is preconsumer recycled wood residual, and it is recyclable.
- Gypsum wallboard. The gypsum board emits nearly no VOCs. It contains 5 percent post-industrial recycled gypsum content and 100 percent recycled content paper face fiber and is recyclable.
- Steel framing. The framing is inherently inert ferrous metal with no VOC emissions. It contains an averaged of 50 percent overall recycled content and is recyclable.
- Countertops. The solid surface acrylic polymer was manufactured without formaldehyde. Ten percent is post-industrial recycled acrylic content, and they are recyclable.
- Toilet partitions. They were manufactured from solid high-density polyethylene (HDPE) plastics without formaldehyde. Seventy percent is preconsumer and post-consumer plastic bottles, and they are recyclable.

Although the environmentally friendly materials used in this project cost more than conventional materials, overall material costs were limited to meet the project budget. This was accomplished by specifying basic materials necessary for completing the building and foregoing more expensive options, selecting materials with recycled content that, in some cases, cost less than conventional products, and using a life-cycle analysis approach to justify selecting more costly, durable products by cost-averaging over the extended life expectancy of the material. This $2.7 million green building renovation was completed at a cost of approximately $37 per metric m^2 (1 ft^2), well within the U.S. average for this type of project.

Ridgehaven results include healthy IAQ through specification of environmentally friendly building materials, more than adequate ventilation, and healthful building maintenance. Approximately 169 metric tons (186 tons) of construction debris and materials were diverted from the landfill through reuse, salvaging, and recycling. Numerous existing building components were refurbished and reused within the renovated building or salvaged for off-site reuse. Water conservation was achieved through water-saving plumbing fixtures that reduced water consumption by approximately 50 percent. Energy efficiency was achieved through energy-saving electrical and mechanical systems. The renovated green building consumes approximately 60 percent less energy than the original building before remodeling, which translates into significant savings. Ridgehaven demonstrates how an environmentally sustainable renovation can create long-term benefits and savings.

The Future is Green

The green building movement will be gathering additional momentum as The Walt Disney Company applies environmentally sustainable strategies to facility development in the next millennium. Its Green Building Goals and Guidelines focus on sustainable building principles and environmental materials. Potential green building benefits include health IAQ, energy efficiency, resource savings, water conservation, improved built environment, enhanced natural ecology, and long-term economical savings.

As more companies and clients become environmentally aware and request the specification of green building products in their facilities and as natural resources are depleted, manufacturers will respond to increased demand and the necessity to develop greener products. A larger selection of environmental product lines may become available along with competitive pricing as more green building materials emerge. Green materials may actually become "conventional" as they replace traditional building products. The future looks green for environmental building materials as they contribute towards a more sustainable future on our resource-limited planet earth. ■

Notes

1. P. Elmer-DeWitt, "Summit to Save the Earth." *Time* (June 1992): 40-58.
2. Deane Evans, "DOE Charts Course for Next Century" *AIArchitect*, Vol. 3 (February 1997).
3. Asher Derman, Ph.D., "Embodied Energy, Air Pollution, and Materials, Part II," *AIA Environmental Resource Guide*, Topic IV.E 1-17 (April 1993).
4. Handy, Sheldon, Whitmore, Hartwell, Zelon, and Pellissari. *Indoor Air Quality in Public Buildings: Vol. I.* U.S. Environmental Protection Agency (September 1988).
5. Environmental Protection Agency. "The Inside Story: A Guide to Indoor Air Quality Facts." (September 1993).
6. Environmental Protection Agency. "Indoor Air Facts: Sick Building Syndrome." Vol. 4 (April 1991).
7. Lynn M. Froeschle, "Renovating Ridgehaven into a Successful Green Office Building," *Environmental Design and Construction* (January 1998).
8. Lynn M. Froeschle, "Ridgehaven Green Office Building," *AIA Environmental Resource Guide* (April 1998).